Neutrino and Astrophysics Scientific Computing

For the various groups,
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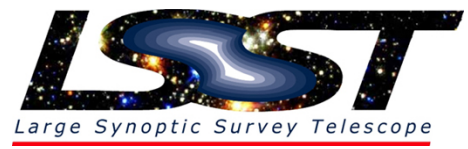
Physics Department

BROOKHAVEN
NATIONAL LABORATORY

DARK ENERGY
SURVEY

LBNE



2011/02/09

Outline

Neutrino Progress

Astrophysics Progress

Plans Going Forward

Summary

BNL Neutrinos:

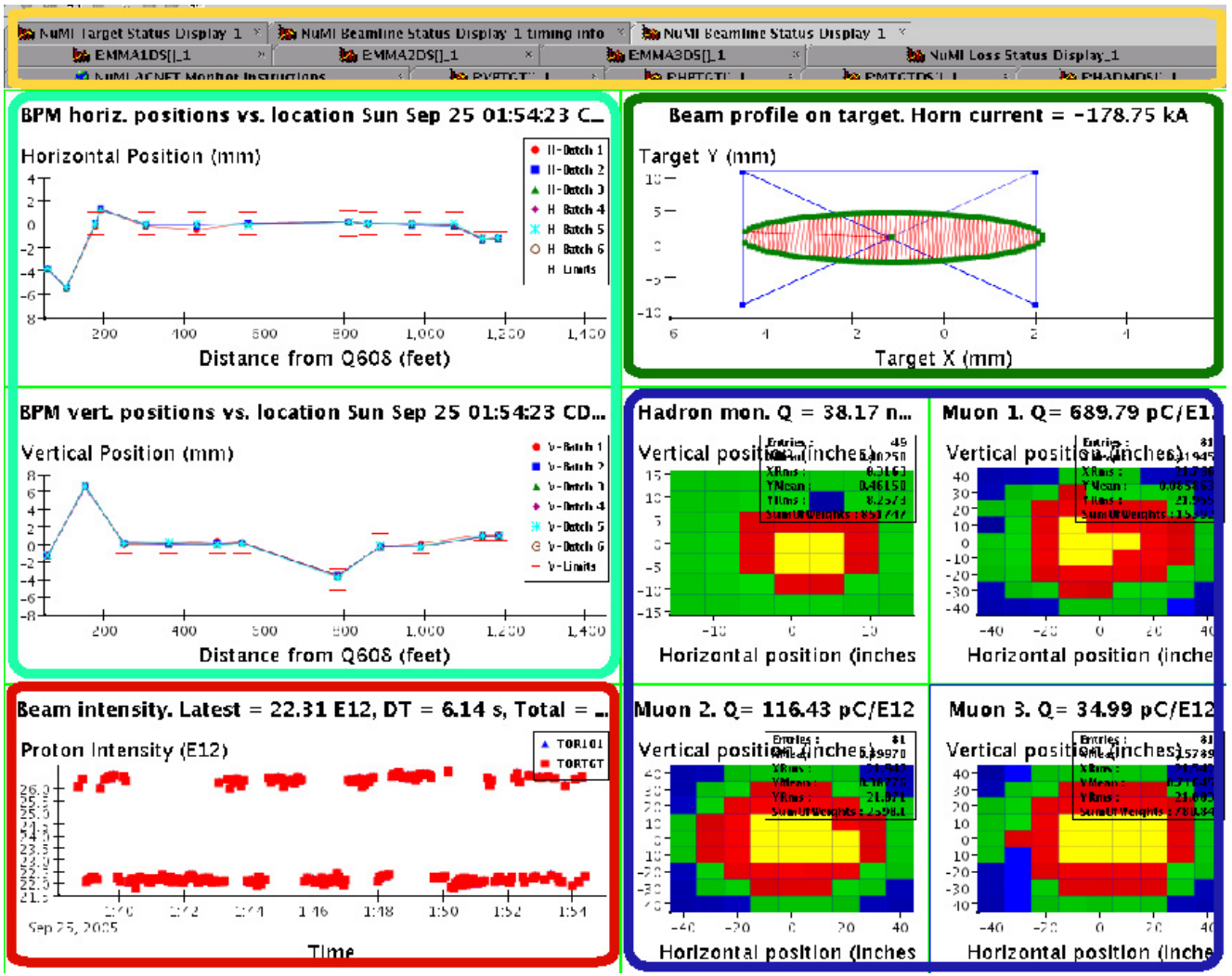
- MINOS long baseline neutrino experiment
- Daya Bay reactor neutrino experiment
- LBNE / Water Cherenkov Detector (WCD)

BNL Astrophysics:

- Dark energy Survey (DES)
- Baryon Oscillation Spectroscopy Survey (BOSS)
- Large Synoptic Survey Telescope (LSST)

MINOS Beam Quality Monitor Application (NuMIMon)

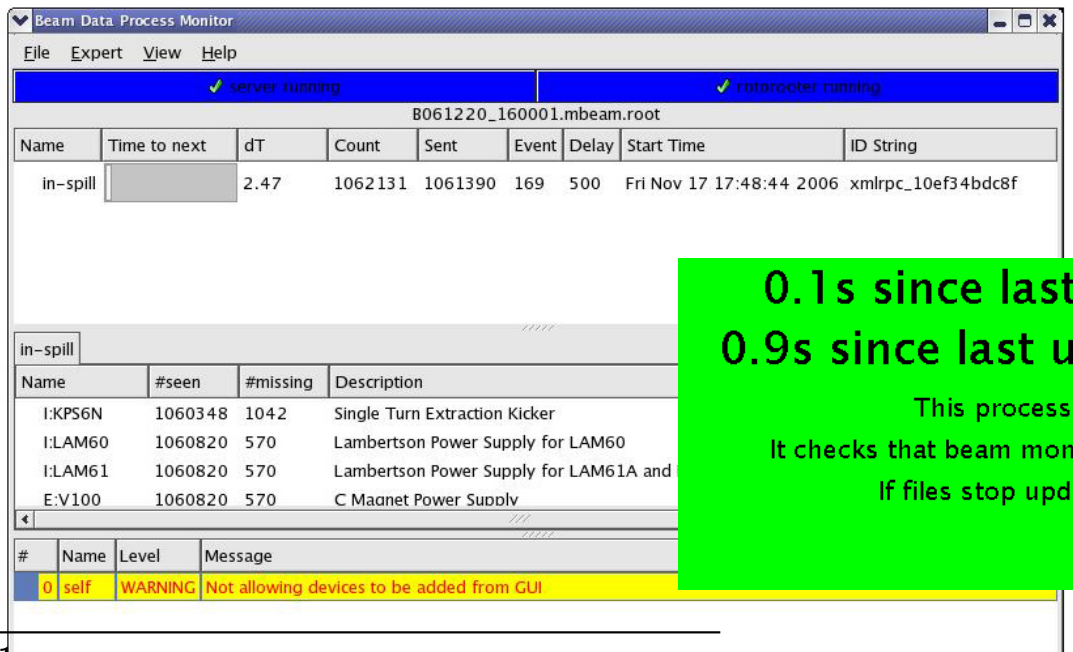
- Spill-by-spill information
- Proton beam position, profile and intensity/power
- Hadron/muon monitor display
- (M. Bishai)



Support and operations mode. Assisting with adoption by Minerνa.

MINOS Beam Data Process

- Readout per-spill information and write to file.
- Fit profile monitors, upload per-spill info to offline database.
- GUI monitors internal state.
- "Big Green Button" monitors output file production[1]
- (M. Bishai, M. Dierckxsens, B. Viren)



In support and operations mode

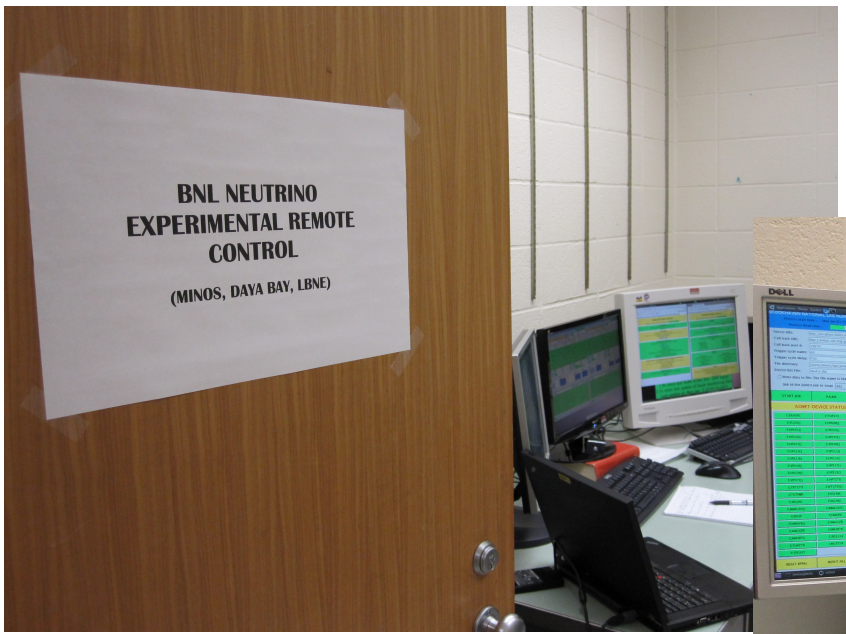
0.1s since last NuMI kicker fire - $A9 signal
0.9s since last update of beam monitoring files

This process monitors beam monitoring data server
It checks that beam monitoring data files are updating with each $A9 signal
If files stop updating you will find further instructions here

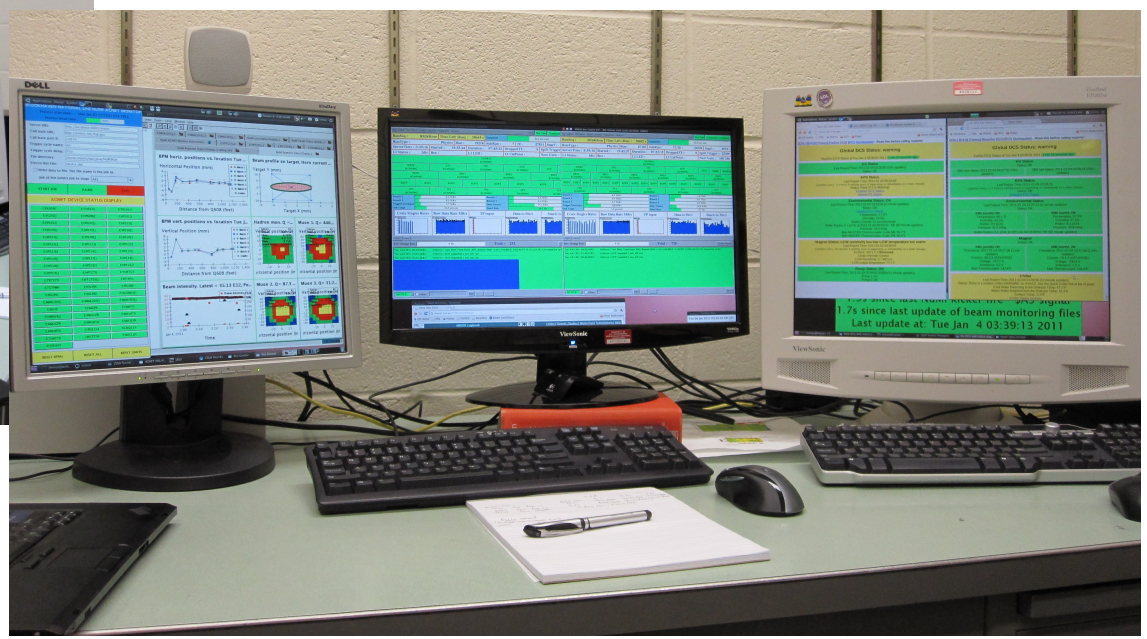
[1] B.Viren, maintainer. R. Ospanov original author.

Remote MINOS Shift

- Collected shift applications, automated their installation and use.
- Developed initial remote shift protocols; took inaugural remote shift.
- Minerνa adopting for their MINOS-related remote shift duties.



Prototype remote shift station.

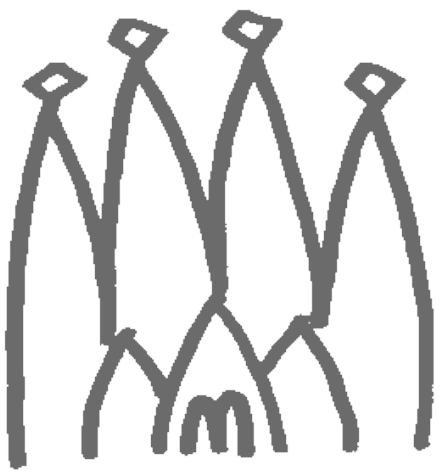


New development.
(B. Viren)

Daya Bay Offline Software

NuWa (Chinese creator goddess / **Nu** at Daya **Wa**n (bay))

- Based on the **Gaudi** framework
  - → Also, take from LHCb: **GiGa** (Geant4/Gaudi interface), **DetDesc** geometry system, **GaudiObjDesc** data description
- Initial adoption and build automation work done by BNL.
- There has been much development in the past three years in the area of Gaudi applications.
  - → Both Daya Bay-specific and general-purpose.
  - → Much of it by BNL



Daya Bay Kinematics Generators

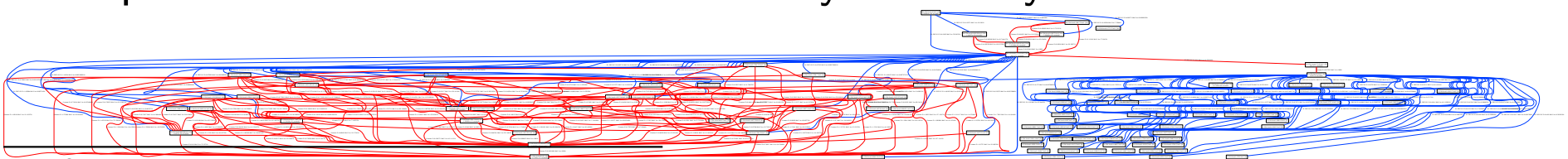
GenTools (B. Viren)

- General purpose, modular Gaudi-tool based generator.
- Plugin different tools, each producing some element of the kinematics, "programming" them with just job configuration.
  - → Positioner, timerator, gun, transformer, special purpose (sources), interface to external executables.
- Produces HepMC objects for later consumption by Geant4.

GenDecay (B. Viren)

- General purpose nuclear decay generator plus a GenTool interface.
- Data-driven with BNL Nat. Nuc. Data Center files, parsed by libmore[2].
- Exact abundance or secular equilibrium adjustable correlation time

Example: $^{234}\mathrm{Th} \rightarrow^{234} Pa \rightarrow^{234} U$ decay hierarchy:



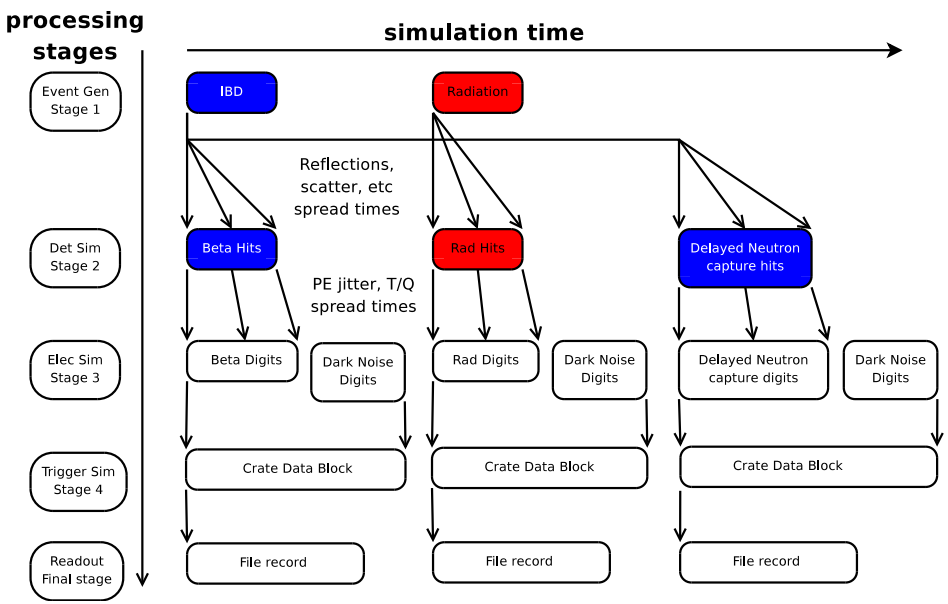
[2] `https://more.sf.net`

Temporal Event Complexity in Daya Bay

Daya Bay has a complex event timeline due to event mixing and pileup.

- Delayed coincidence of inverse-β decay from reactor neutrinos followed by neutron absorption ($\sim 30\mu$s)
- Cosmic-μ followed by fast neutron or $^{9}\mathrm{Li}/^{8}\mathrm{He}$ production ($\sim 30\mu$s)
- Radioactive backgrounds with correlated daughter decays possible (various time scales)
- Accidental pileup and out-of-order hits due to geometry (10s ns)
- Mixing of unrelated events can happen at kinematic generation, detector simulation and trigger levels.

Must properly simulate this complexity



Solution: Just-in-time Simulation for Event Mixing

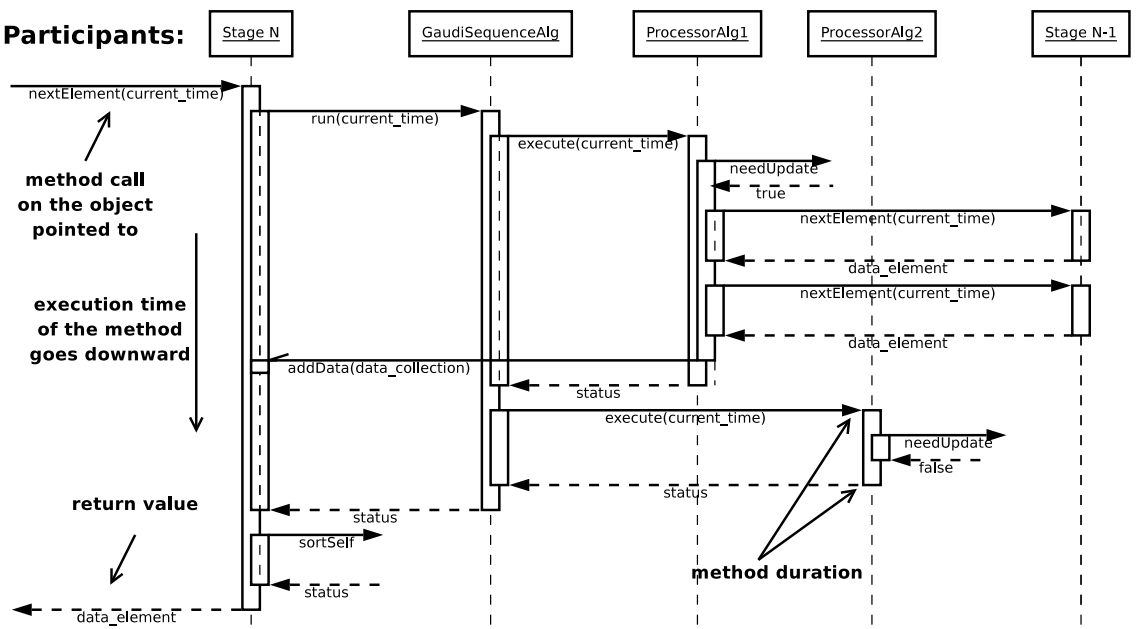
Break simulation into discrete stages.

Then, turn the simulation around, backwards.

1. Start by asking readout stage for an event.
2. Readout asks trigger stage for a trigger.
3. Trigger stage asks electronics stage for latest digitizations.
4. Electronics asks detector stage for latest hits.
5. Detector stage asks generator stage for latest kinematics.
6. Recursion returns just enough simulation to satisfy requests.

Sequence UML diagram
for 2-stage interaction.

(D. Jaffe, B. Viren, Z. Wang)



Daya Bay User Environment Management System

Daya Bay release model:

- Multiple, central releases at each site (opt & debug + versions) containing several CMT projects.
- Personal projects, potentially overriding package in central release.

Potential headache, needs experiment-wide solution: **nuwaenv**

```
# site configuration file
[defaults]
base_release=/path/to/%(release_name)s/%(opt_or_dbg)s
release_name=trunk

[production]
release_name=v1r0p0

# user's configuration file
[myana]
project_dir=/home/bv/myana
package = AnaRelease
```

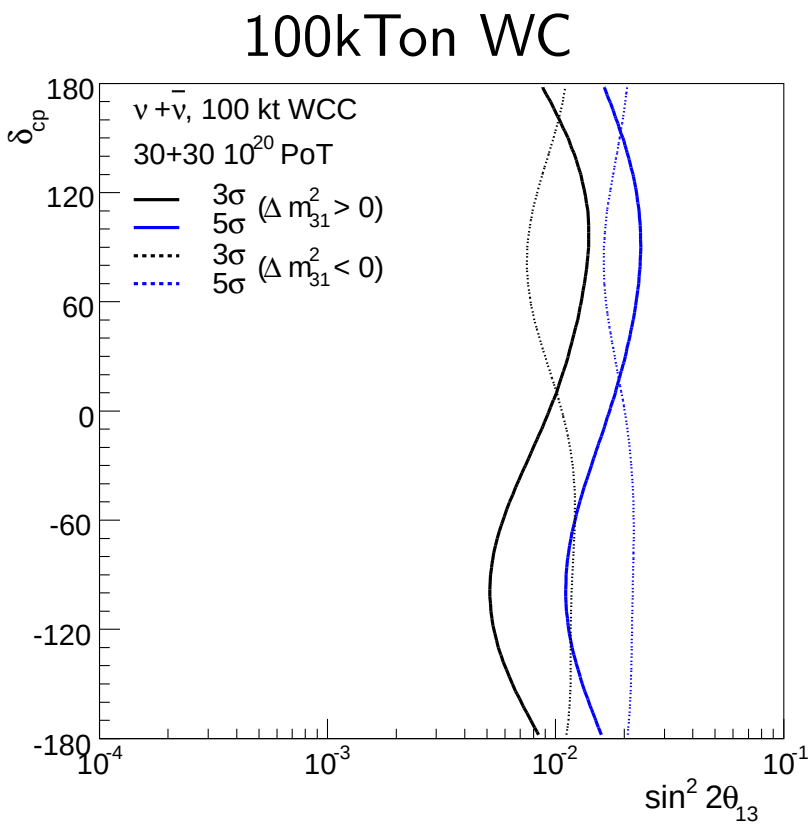
```
# Set up optimized, production
$ nuwaenv -O -r production
# Augment with personal project
$ nuwaenv -p myana
```

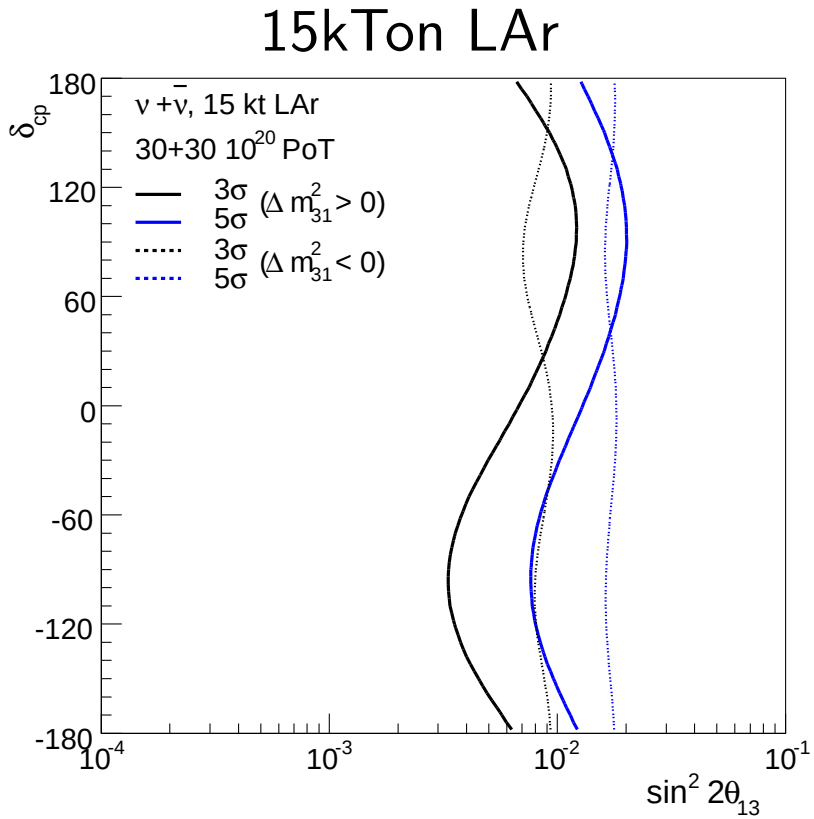
Everyone learns the same setup command. Configuration left to the release admin and extended by user.

(B. Viren)

Application of GLoBES for LBNE Sensitivity Calculations

General **Lo**ng **B**aseline **E**xperiment **S**imulator – fast simulation.





(M. Bishai, M. Dierckxsens)

GARPI – **G**audi **A**nd **R**elated **P**rojects **I**nstaller

- Inspired by Daya Bay's automated installer developed by BNL.
- Written initially for LBNE's Water Cherenkov far detector (WCD) group
  - → General purpose, can be used by other experiments.
- Automates installation of Gaudi or similarly configured projects.
  - → Divines required externals by analyzing project requirements, downloads source and builds the packages.
  - → Builds the projects themselves.
- Includes environment management system similar to Daya Bay's `nuwaenv`.

Development based at:
`http://www.phy.bnl.gov/trac/garpi`
(B. Viren)

Current Neutrino Hardware Procurement

Daya Bay:

- 48 cores
- 16 TB disk

LBNE/WCD:

- 160 cores
- 55 TB disk

Characteristics common to both sets of nodes:

- 16 HT core per box, intel x5550 @ 2.67GHz, 8.8 HEP-SPEC06/core
- 1.5 GB RAM/core
- Purchased in 2009, hardware EOL in 2013
- Scientific Linux 5.3, 64bit
- Managed by and housed in BNL's RACF
- Open to all members of the respective collaborations

Neutrino Progress

Astrophysics Progress

Plans Going Forward

Summary

DES – **D**ark **E**nergy **S**urvey

Measurement of gravitational shear effect in astronomical images
(E. Sheldon)

- Developed a DESWL (Weak Lensing) framework to process large amount of DES data in parallel.
- Pipelines for processing single epoch data and combining multi-epoch data.
- Tested on all available simulated DES data.
- Code delivered regularly to DES data management team for inclusion in annual DES Data Challenges.

Baryon Oscillation Spectroscopy Survey

- Erin Sheldon is main coordinator and developer for the BOSS target selection effort - a crucial piece of the infrastructure
- Anže Slosar leads the developement of the data-reduction pipeline LYAFER, that converts calibrated spectra to measurements of the flux correlation function. This can be used to constrain dark energy with BOSS quasar spectra
- By working with data, Slosar provides feedback to primary data reduction pipeline developers.

LSST – **L**arge **S**ynoptic **S**urvey **T**elescope

- Analysis of CCD test images towards LSST sensor effort (J. Frank).
- BNL's Blue Gene supercomputer used for simulations of cosmological gravitational lensing.

Current Astrophysics Hardware Procurement

- Currently 44 nodes in total, residing in BNL's RACF
- 24 nodes $\times$ 8 cores, 3 TB storage and 32 GB per node.
- 20 nodes $\times$ 2–4 cores, 0.8 TB storage and 4–8 GB per node.

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Astrophysics Progress

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Summary

Neutrino Scientific Computing Plan

MINOS ramping down effort, in maintenance mode.

Daya Bay as part of operations, triple current hardware in RACF and increase disk storage followed by periodic replacement of obsolete nodes. Keep 10% reduced sample on local disk. Offline software maturing, transition to data analysis. Evaluating **PanDA** for unified batch processing on US farms.

LBNE project plan to continue leveraging BNL/RACF for WCD computing resources. Near term, maintain current node count, replacing nodes as they reach EOL. Significant hardware ramp-up nearing commissioning. Requirements based on scaling from Super–Kamiokande experience, fairly solid. For software, following lessons from Daya Bay in leveraging Gaudi and other software including packages from Daya Bay itself.

Astrophysics Scientific Computing Plan

DES Survey runs 2011–2016, weak lensing analysis to be centered at BNL. Expand hardware to ∼70 nodes (26kSI2k, 104 HEP-SPEC 2006 for full analysis). Expect some resource sharing with BOSS.

BOSS Survey runs 2009–2014, focus on Lyman-α, constrain dark energy, neutrino mass and inflationary physics. Expand to ∼30 total nodes.

LSST Additional computing needed for dark energy science. Funding to begin outside of 3-year period, planning to start soon. Will participate in Dark Energy Data Center, BNL interested to host. RACF makes hosting extremely cost effective.

MCCI – Midrange Computational Cosmology Initiative

- A four lab initiative: SLAC, FNAL, LBL, BNL
- A. Slosar a proposal co-PI.
- Modeled after Lattice QCD proposals.
- Proposal will be submitted soon (Feb 2011)
- Goal is to run a compendium of simulations covering all major cosmological probes
- All resulting catalogs and codes will be public
- Asking for $10 million over 5 years for entire project
- BNL responsible for Lyman-α simulations part of the initiative: a nice, self-contained niche
- Simulations will be used in interpreting BOSS, DES and LSST data.

MCCI is separate from other astro-computing ramp-up.

Summary

Neutrinos:

- MINOS work ramping down. Beam-related transitioning to Minerνa.
- Significant progress in software Daya Bay development
- Starting to leverage Daya Bay work for LBNE.
- Leveraging of RACF expertise is meeting Daya Bay and LBNE requirements, plan to continue to make use of this resource.

Astrophysics:

- DES weak lensing framework code tested on simulation and regularly delivered for annual Data Challenges.
- BOSS target selection effort crucial infrastructure, completed for next year or so of observations.
- Existing hardware installation is meeting current needs, expansion to $\sim$100 nodes for DES and BOSS planned for meeting future goals.
- Participating in MCCI proposal.